Implications of the unusual structure in the pp correlation from Pb+Pb collisions at 158 AGeV [1]

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The recent NA49 measurement of two-proton correlation function shows an interesting and unexpected structure at large relative momentum [2]. We have inverted the measured correlation function using the source imaging techniques [3], and obtained a two-proton source function that is consistent with a sharp-edged source with radius ~ 10 fm. We find that the sharp edge is due to the structure in the correlation; the edge can be removed by smoothing out the structure.

Correlation functions are often described by the standard Koonin-Pratt formalism [4]. The formalism makes two assumptions: (1) The source function only has a weak dependence on relative momentum corresponding to off-shell particles (smoothness assumption); and (2) the two-particle source is a convolution of single-particle sources (independent emission assumption). If we neglect the dependence of the source function on the two-particle relative momentum, then we can prove that the Fourier transform of a source must be positive everywhere. However, the inverted NA49 source is not, implying that the source does not fulfill one or more of the underlying assumptions.

In the case that there is a strong low relative momentum dependence in the NA49 source function, such a dependence cannot be reconstructed by the imaging. One would think that such a dependence of the source might result from strong position-momentum correlations in the single-particle sources. However, model studies do not support such a supposition.

In the second case, the NA49 two-proton source is not a convolution of two independent sources. In this case, interpreting the source function becomes difficult as we cannot model it simply with a transport model. It has been suggested that this possibility could occur if there are hidden correlations in the system [5]. Such hidden correlations would arise from having three or more dynamically or statistically correlated particles in the final state while only observing two of them.

Finally, in the event that the smoothness assumption is no longer valid, the entire formalism breaks down. This is the worst possible case from our standpoint as we cannot apply our imaging procedure. Pratt argues that this could be caused by strong off-shell effects and these effects would be magnified by strong position-momentum correlations in the source and by the short-range interaction between the protons [6]. Pratt comments that these effects are larger in small systems, e.g. with single-particle source size $R \sim 1$ fm, much smaller than the source imaged here.

References

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